

SYNOPSIS V1.0:
Heavy Ion Latch-up and Transient and Laser Transient Test Results
for the Analog Devices OP293 Operational Amplifier

Ray Ladbury¹ and Hak Kim²

1. Orbital Sciences Corp.
2. Jackson and Tull Chartered Engineers

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I. INTRODUCTION

This study was undertaken to determine the heavy-ion induced single-event latch-up (SEL) and single-event transient (SET) sensitivities of the Analog Devices (ADI) OP293 operational amplifier. The testing was done at the Texas A&M University Cyclotron Institute in College Station, TX. The power supply current was monitored for large increase, and the device's functionality was verified after each single event latchup (SEL). Transients were counted and recorded for later study.

II. DEVICES TESTED

The OP293 is a precision, micropower op amp fabricated in ADI's complementary BiCMOS process.

Two samples of the device were tested, both with date code 0021. Caution is appropriate when dealing with commercial devices, since die from different wafer lots may be packaged at the same time, and would have the same lot date code.

III. TEST FACILITY

Facility: Texas A&M University Cyclotron Institute.

Flux Range: 5×10^3 to 3×10^5 particles/cm²/s.

Particles: linear energy transfer (LET)

Ion	LET (MeVcm²/mg)
Ar	8.45
Cu	19.95
Ag	42.85

IV. TEST METHODS

Temperature: ambient and elevated temperature (~80-85 degrees C)

Test Hardware: An VXI-based custom test set was used to supply nominal input levels to the DUTs and monitor the bias supply current for changes resulting from the radiation exposure. Files were generated for each DUT to track changes the supply current with a measurement accuracy of 100 pA. The current was measured and recorded at 10 ms intervals throughout the exposure. An oscilloscope was used to monitor DUT functionality and count and capture transients during the irradiation.

Software: Customized LABVIEW[®] software provided a user interface to control signals to the DUT. The software also automatically monitored supply currents and generated a file history. In the event that the supply current exceeded a predefined value, called the limiting current (I_L), the software automatically turned off the DUT power supply.

Test Techniques: Tests were performed to screen for susceptibility to latch-up and measure latch-up sensitivity as a function of particle LET. A secondary goal was to determine the susceptibility of the OP293 to transients. The devices were tested at their application voltage ($V_{cc} = 5$ V) and at both ambient and elevated temperature. An equivalent normal-incidence fluence of at least 1×10^7 ions/cm² was used at each test condition unless an SEL occurred. A beam flux range of 5×10^3 to 3×10^5 particles/cm²/s resulted in individual exposures between 33 second and 10 minutes.

Device functionality was monitored by varying the input to the chip and verifying that the output also changed. If the device current experienced a sudden increase larger than I_L , the power was cycled and the DUT was checked for functionality; we called this an SEL. The DUT functionality information was not saved to a file, but was recorded in the run log.

V. RESULTS

The OP293 did not exhibit SEL for effective LETs up to 85.7 MeVcm²/mg and for particle fluences up to 1.0E7 particles per cm². Effective LETs were obtained by varying the angle of incidence of the particle beam relative to the die surface's normal. This allows testing at LET values other those given in the table in section III.

However, the device did exhibit significant transients with magnitudes up to the rail and durations more than 200 μ s. These transients are significantly longer than those typically observed for linear bipolar devices, and could pose significant concerns for some applications.

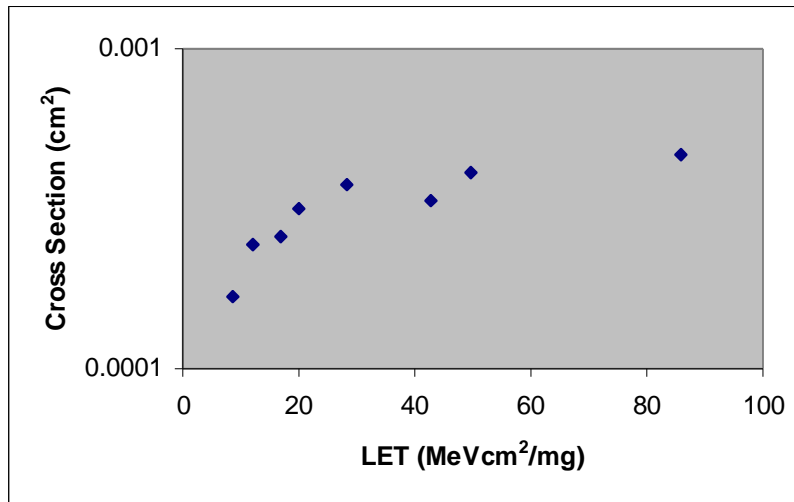


Figure 1 Cross section for all transients vs. LET

Due to lack of time, the LET threshold for transients could not be determined. It is likely that given the slow drop off of the cross section vs. LET curve, the threshold will be about 1 MeVcm²/mg. However, there was a strong correlation observed between LET and the magnitude and duration of the transients. The threshold for transients lasting longer than 200 microseconds was about 16 MeVcm²/mg, and that for transients lasting longer than 150 microseconds was about 10 MeVcm²/mg. Even so, transients lasting longer than 100 microseconds occurred at the lowest LET values used, and transients lasting longer than 50 microseconds were common.

Figure 2 shows a “typical” long transient profile. Note that the duration of the transient extends beyond the end of the sample interval, yielding an estimated duration of about 250 microseconds. Some transients showed durations of greater than 300 microseconds.

In an effort to better understand the transient behavior of this device, delidded parts were tested with a laser at the Naval Research Laboratory. Long duration transients were observed during these tests, with maximum durations longer than 600 ms. The duration of the transient seemed to be proportional to the difference between the rail voltage and the nominal output voltage. This means that for a rail voltage at the maximum rating for the part and a nominal output voltage at 0, it may be possible to see transients lasting longer than 1 ms.

The vulnerable area on the die was large and did not correspond to any single visible feature on the die. It was noted that the long duration transients were not seen when the die was illuminated by ambient room light.

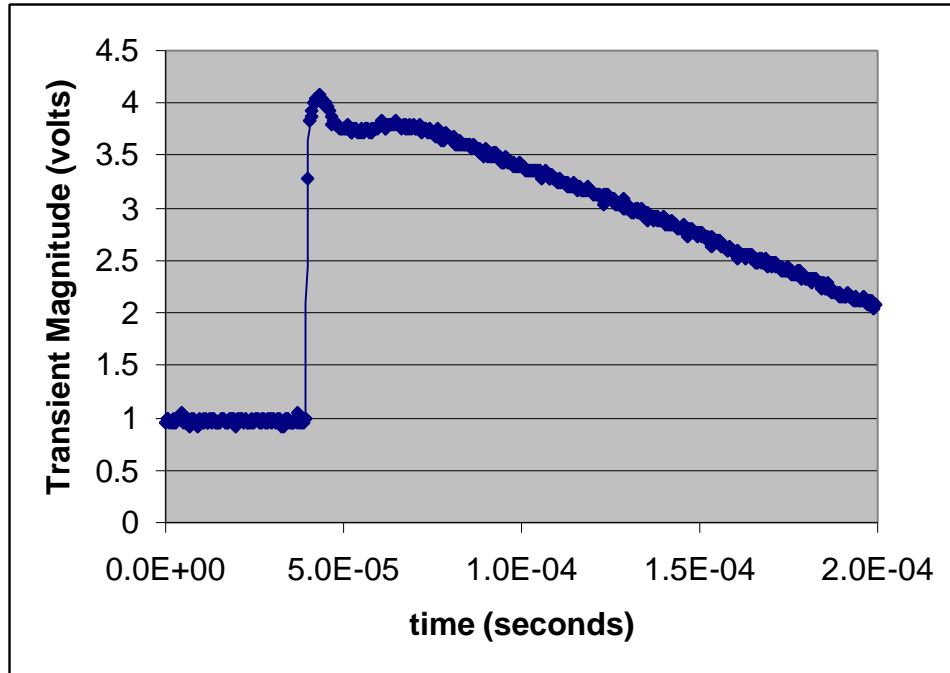


Figure 2 Profile of a long transient from the OP293.

VI. COMMENTS AND RECOMMENDATIONS

In general, the REA group does not recommend the use of devices in space flight applications that experience an SEL at an LET less than or equal to $37 \text{ MeV cm}^2 / \text{mg}$. Significant error mitigation approaches capable of detecting an increase in current and responding to rapidly cycle power would be required if these devices are used in a space flight application. The extent of degradation of device lifetime and reliability due to an SEL are unknown.

Although the OP293 did not exhibit any SELs or other destructive failure mechanisms, it is susceptible to the longest duration severe single-event transients (SETs) yet seen from a linear microcircuit. Past testing has shown that the transient response of linear devices can be quite dependent on application conditions. If SETs are a concern, additional testing may be necessary.